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PLANT MATERIALS TECHNICAL NOTE

Effect of Seedling Root Length on the Survival and Establishment of Plains Cottonwood *Populus deltoides* in a Riparian Planting in Eastern Montana

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Figure 1. A 36-inch deep pot and plains cottonwood seedling (NRCS photo).

ABSTRACT

Successful reintroduction of plains cottonwood, *Populus deltoides,* in riparian corridors is often inconsistent or limited. In an attempt to improve survival and growth of plains cottonwood, a replicated study was installed in collaboration with the Agriculture Research Service (ARS), Fort Keogh Livestock and Range Research Laboratory along the Yellowstone River near Miles City, Montana, in 2011. A local seed source of plains cottonwood was used to propagate seedlings in 2-inch wide (inside diameter) by 10-, 24-, and 36-inch long containers and PVC pipe. Ten seedlings

of each container size (root length) were planted in each of 3 subplots. Subplots were arranged with increasing distance and elevation from the river. Data was collected annually on seedling survival, height growth, caliper growth, and vigor rating. Effect of container size (root length) and subplot location (distance from the river and elevation) were analyzed. There was a statistical difference between the 10-inch containers, and the 24- and 36-inch containers for seedling survival. There was no statistical difference for seedling survival among the 3 subplots with distance from the river (total elevation differential of approximately 0.45 feet). Seedlings had the greatest annual height growth in subplot III (farthest from the river and greatest elevation – 95 cm), followed by subplot II (83 cm) and I (closest to the river and lowest elevation – 73 cm). Seedlings had the greatest annual height growth in 2013 (139 cm), followed by 2014 (104 cm), and then 2011 (50 cm) and 2012 (43 cm). Annual height and caliper growth were not influenced by container size. Differences in annual caliper growth were only affected by elevation, and only in 2012, when seedlings had greater caliper growth in subplot III (21 mm) than subplot II (18 mm). Regression models suggests vigor ratings are at best approximately 40% accurate in estimating annual height and caliper growth, and there are sizeable differences among years. Results suggest increased survival may be achieved by planting seedlings with 24- and 36-inch long root systems, and planting site selection, at least within the limited range of this study, may influence seedling height and, to a lesser degree, caliper growth, but results were inconsistent and varied by year.

INTRODUCTION

As a result of invasive plant species, changes in water management, and variable weather patterns, natural recruitment and establishment of plains cottonwood is limited in many riparian corridors in Montana and Wyoming. Vegetative practices such as Tree and Shrub Establishment (612) and Riparian Forest Buffer (390) have been used to establish plains cottonwood in riparian zones, but success has been limited. Study hypotheses were: 1) seedling root length (container size) effects seedling survival and growth, 2) distance from the river impacts plant survival and growth, and 3) seedling root length effects on plant survival and growth depend on planting site location (distance from the river). Plant performance measures included survival, height growth, basal caliper growth, and vigor rating. This Technical Note summarizes the findings of the study.

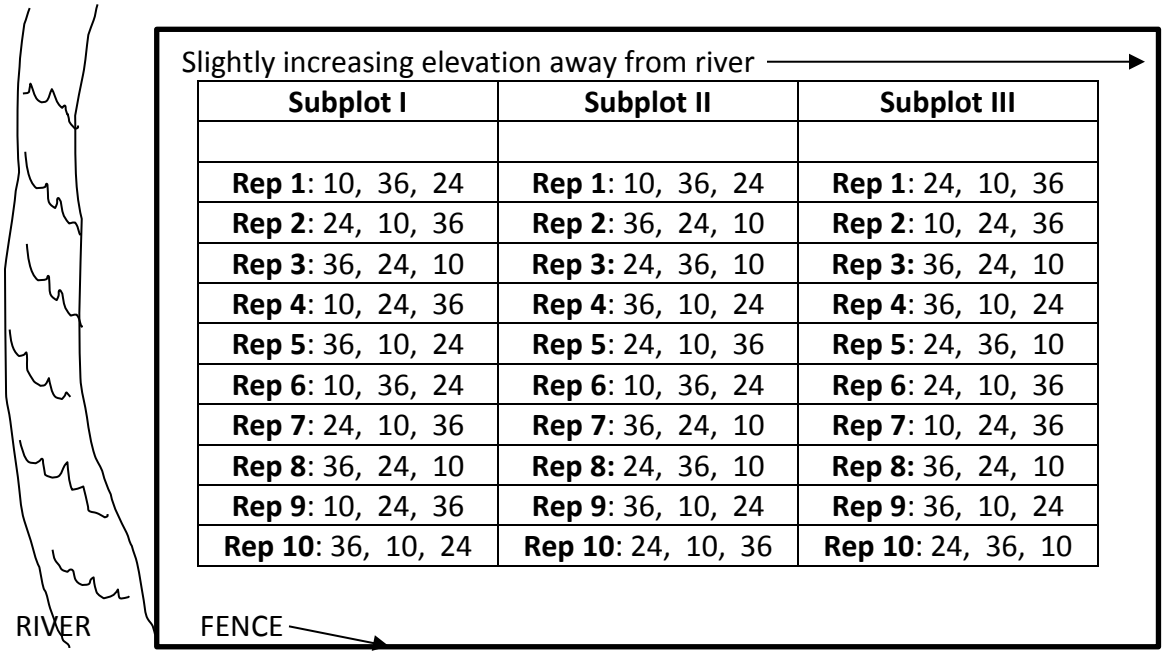
MATERIALS AND METHODS

In preparation for the study, plains cottonwood seed was collected in 2009, processed, and sown in 7-cubic-inch containers. Seedlings were overwintered in a coldframe maintained slightly above freezing. The seedlings were transplanted into 10-, 24-, and 36-inch deep pots, respectively, in early 2010 (Figure 1).

The study site consisted of a decadent crested wheatgrass (*Agropyron cristatum*) pasture. The plot was mowed and then sprayed with glyphosate (spring 2012) and then rototilled prior to planting (Figure 2).

Figure 2. Plains cottonwood deep pot study test plot preparation (NRCS photo).

The study design was a randomized complete block consisting of ten plants of each container size randomized within three subplots and replicated 10 times (Figure 3). The site is in USDA Winter Hardiness Zone 4a. Mean annual precipitation in the area ranges from approximately 12 to 14 inches.



Subplot I	Subplot II	Subplot III
Rep 1: 10, 36, 24	**Rep 1**: 10, 36, 24	**Rep 1**: 24, 10, 36
Rep 2: 24, 10, 36	**Rep 2**: 36, 24, 10	**Rep 2**: 10, 24, 36
Rep 3: 36, 24, 10	**Rep 3:** 24, 36, 10	**Rep 3:** 36, 24, 10
Rep 4: 10, 24, 36	**Rep 4**: 36, 10, 24	**Rep 4**: 36, 10, 24
Rep 5: 36, 10, 24	**Rep 5**: 24, 10, 36	**Rep 5**: 24, 36, 10
Rep 6: 10, 36, 24	**Rep 6**: 10, 36, 24	**Rep 6**: 24, 10, 36
Rep 7: 24, 10, 36	**Rep 7**: 36, 24, 10	**Rep 7**: 10, 24, 36
Rep 8: 36, 24, 10	**Rep 8:** 24, 36, 10	**Rep 8:** 36, 24, 10
Rep 9: 10, 24, 36	**Rep 9**: 36, 10, 24	**Rep 9**: 36, 10, 24
Rep 10: 36, 10, 24	**Rep 10**: 24, 10, 36	**Rep 10**: 24, 36, 10

Figure 3. Plains cottonwood deep pot study layout.

The soil is classified as 452A - Glendive loam (0 to 2 percent slopes, rarely flooded), with mean depth to gravel and mean percentage clay increasing with distance and elevation from the river (Table 1).

Table 1. Mean depth to gravel and mean percentage clay.

Proximity to River	Depth to Gravel	Mean Percentage Clay at <~10"	Mean Percentage Clay at <~24"	Mean Percentage Clay at <~36"
	inches	*%*	*%*	*%*
Subplot I (closest to river)	31.3	8.8	14.3	17.0
Subplot II (middle)	32.8	10.6	17.7	NA
Subplot III (farthest from river)	39.9	14.7	22.2	20.0

An 8-foot tall animal exclusion fence (Practice Specification MT 382) was constructed around the entire test plot prior to planting. Planting holes were drilled with a 10-inch auger, seedlings planted, watered in with 3 gallons of water, and woven, 6-mil weed fabric installed along the entire test rows. Vegetation in fallow areas between rows and fabric were periodically managed with mowing and herbicide applications (Figure 4).

Figure 4. Completed plains cottonwood deep pot study test plot (NRCS photo).

Plant survival, height, basal caliper, and vigor rating data was collected annually for several years. Soil tensiometers were placed at 1-, 2-, 3-, and 4-foot depths in each subplot to record soil moisture conditions over time and climatic data recorded daily (not presented here). Kaplan-Meier Product Limit Survival Distribution was used to analyze survival data. Annual height and caliper

growth data was analyzed with analysis of variance and Tukey's HSD test was used to separate significant means at the 5% level of probability. Vigor rating relationship to height and caliper growth was analyzed using regression analysis.

RESULTS

Survival

Mean percentage survival results over time appear in Figure 5. By fall of 2011, mean percentage survival measured 80% (10-inch containers), 97% (24-inch containers), and 100% (36-inch containers). One 36-inch container died in 2012, but appeared to be the result of insect predation. There was a statistical difference at the 85% confidence interval in survival between 10-inch containers and the 24- and 36-inch containers. There were no statistical differences in survival at the 95% confidence interval. There was no statistical difference for seedling survival among the 3 subplots (total elevation differential of approximately 0.45 feet).

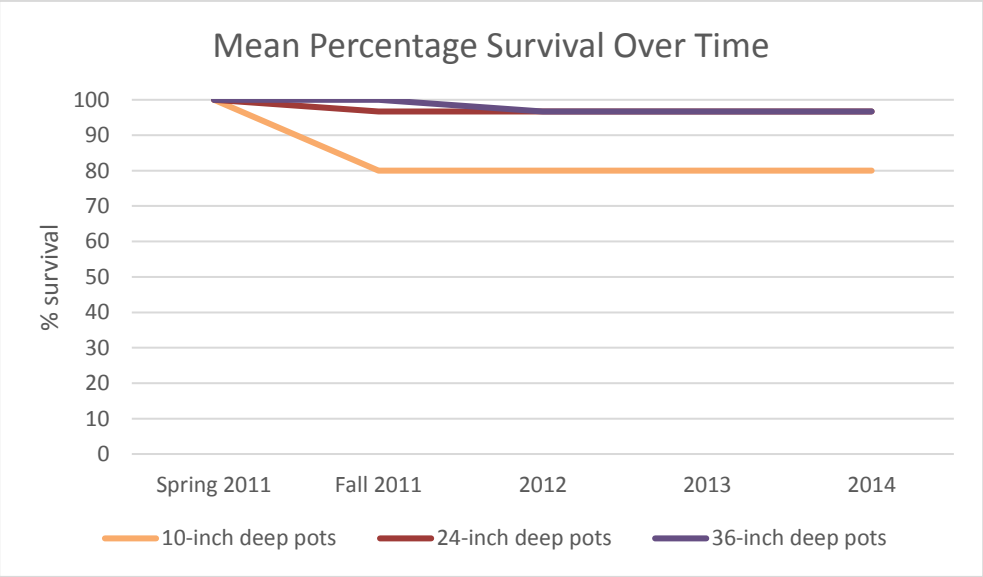


Figure 5. Mean percentage survival over time, USDA-NRCS Bridger, MT, 2011-2014

Height Growth

Mean seedling height (cm) and mean seedling annual height growth (cm) over time are presented in Figures 6 and 7, respectively. The three-way interaction for height growth suggests initially (2011) only trees in the 10-inch containers grew significantly greater in subplot III (farthest from the river, greatest elevation) than subplots I and II (relatively closer to the river and lower elevation). In 2012, seedling height growth was greater in subplot III than subplot II, but not greater than subplot I. This was probably due to the 36-inch container seedlings having greater height growth in subplot III than subplots II and I. In 2013, seedlings growing in subplot III produced greater height growth than seedlings grown in subplots II and I. This difference in height may be attributed to the 24-inch container seedlings producing greater growth in subplot III than subplot I, but not different than subplot II. In 2014, all seedlings had greater height growth in subplot III and II than subplot I, regardless of pot size.

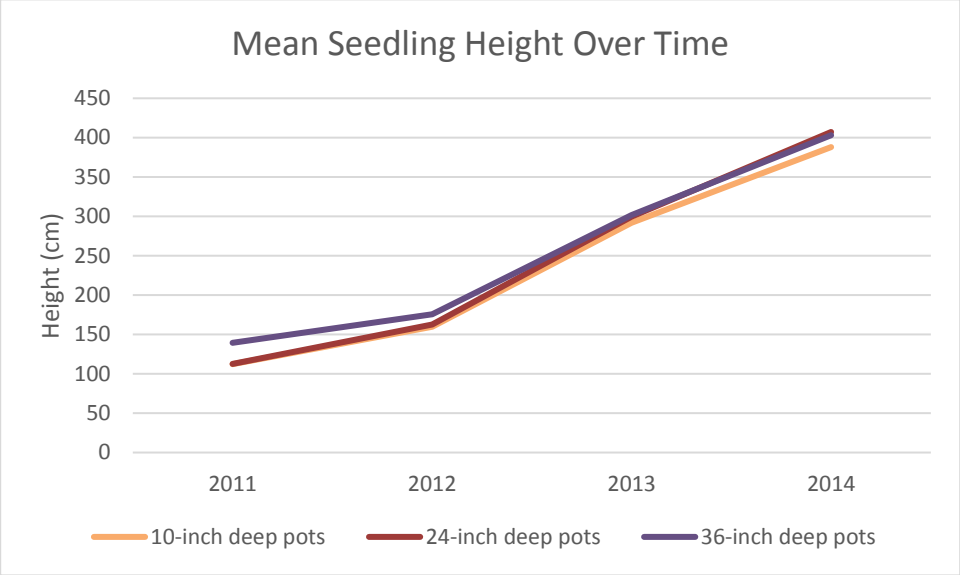


Figure 6. Mean seedling height over time, USDA-NRCS Bridger, MT, 2011-2014

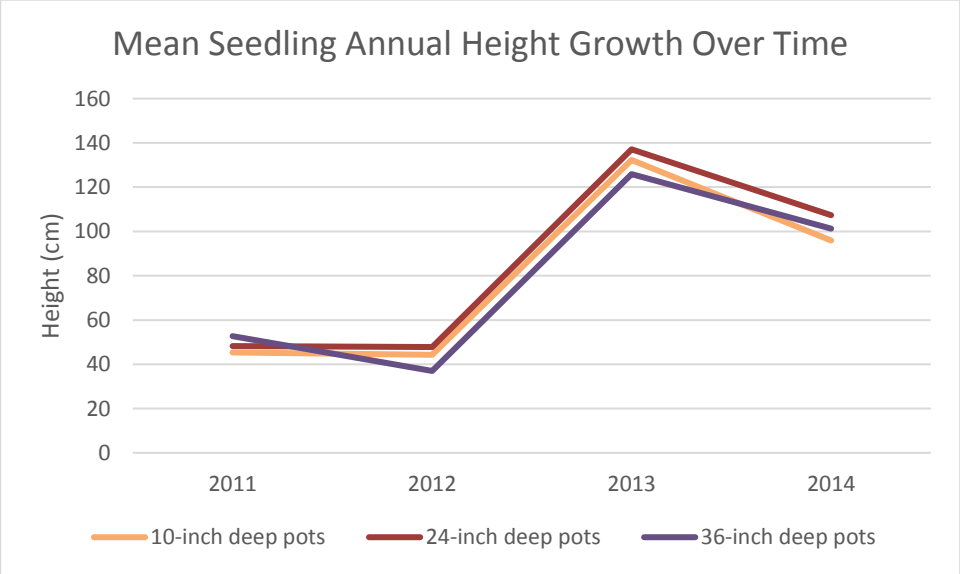


Figure 7. Mean seedling annual height growth over time, USDA-NRCS Bridger, MT, 2011-2014

Greater height growth associated with increasing distance and elevation away from the river probably reflects the increasing percentage of fine soil particles in the soil profile there, presumably resulting in increased water holding and nutrient exchange capacities, among other factors.

Mean seedling basal caliper (mm) and basal caliper growth (mm) over time appear in Figures 8 and 9, respectively. Caliper data was not normally distributed and transformation did not normalize the data. The results suggest year and elevation affected caliper growth but container size did not. Elevation affected caliper growth only in 2012, when seedlings had greater caliper growth in subplot III than subplot II.

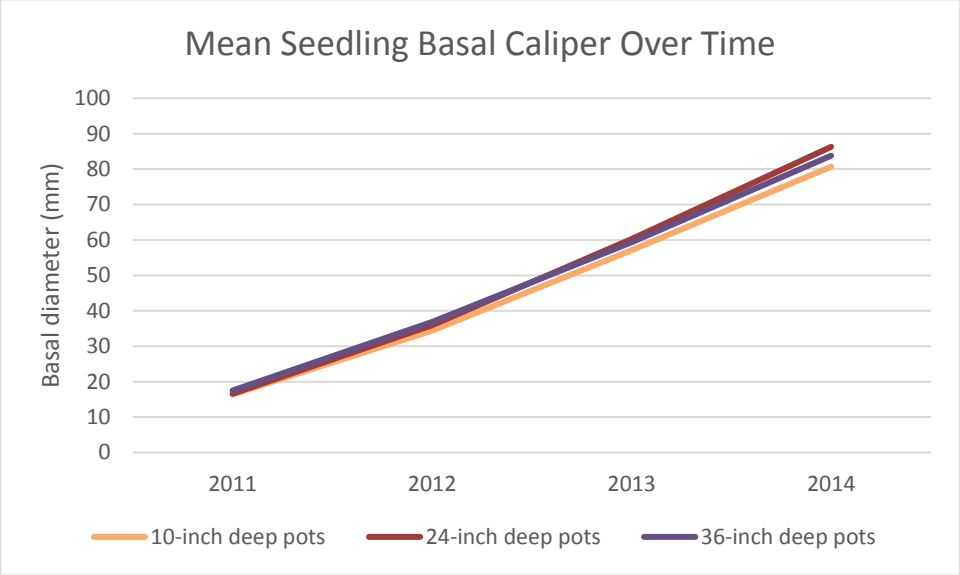


Figure 8. Mean seedling basal caliper over time, USDA-NRCS Bridger, MT, 2011-2014

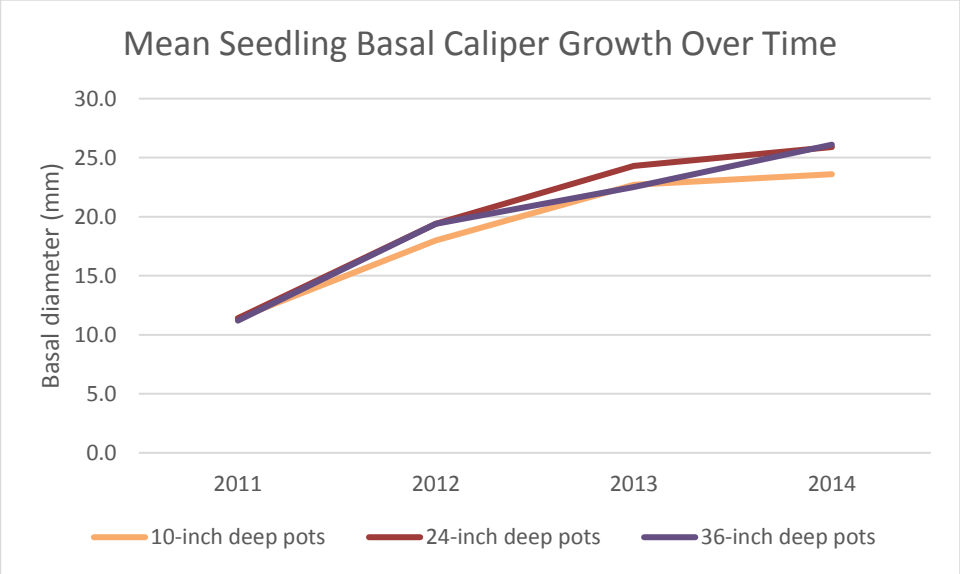


Figure 9. Mean seedling basal caliper growth over time, USDA-NRCS Bridger, MT, 2011-2014

Mean seedling vigor rating over time appears in Figure 10. Differences among container sizes were relatively small, and all means suggested good vigor which improved with time. Vigor as a predictor of height and caliper growth using regression analysis with annual growth measures suggest vigor ratings are at best approximately 40% accurate in estimating height and caliper growth , and there are sizeable differences among years.

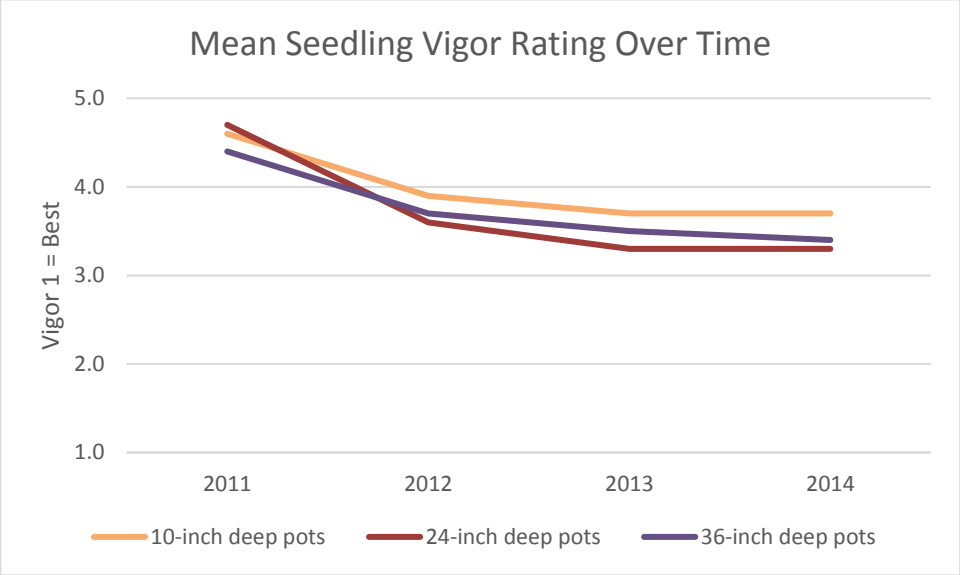


Figure 10. Mean seedling vigor rating over time, USDA-NRCS Bridger, MT, 2011-2014

NRCS Application

1.) Although percentage seedling survival was greater with the 24- and 36-inch containers, the survival of plants in the 10-inch containers (80%) was adequate for meeting plant survival requirements in Tree and Shrub Establishment (612) and Riparian Forest Buffer (390) conservation practices.

2.) Inconsistent but improved height and caliper growth associated with increasing distance and elevation away from the river probably reflects the increasing percentage of fine soil particles in the soil profile there, presumably resulting in increased water holding and nutrient exchange capacities, among other factors.

3.) Overall good seedling survival, growth, and vigor probably reflects proper site preparation and maintenance, including control of herbaceous plant competition, the use of weed fabric, and animal exclusion. It is also likely that well adapted nursery stock produced from local seed sources contributed to good overall plant survival and growth.

4.) Study results support using established NRCS practices and procedures for establishing plains cottonwood, and other woody species, along Montana and Wyoming river corridors.

5.) Site selection may increase plant height and caliper growth in some cases.

Cost analyses may determine the additional cost of production and installation of deep pots is offset by increased seedling survival for certain applications and situations.